Is the hemispheric symmetry of TOA reflected shortwave radiation surprising?

Aiko Voigt

Jürgen Bader, Thorsten Mauritsen, Bjorn Stevens

Max-Planck-Institut for Meteorology, Hamburg

Outline

1. How large is the hemispheric difference in TOA reflected shortwave radiation?

CERES EBAF tells us that the two hemispheres reflect the same amount of shortwave radiation. The hemispheric difference is smaller than 0.2 Wm^{-2}.

2. Is the hemispheric symmetry surprising?

We investigate if the symmetry is a property of any random half of Earth.

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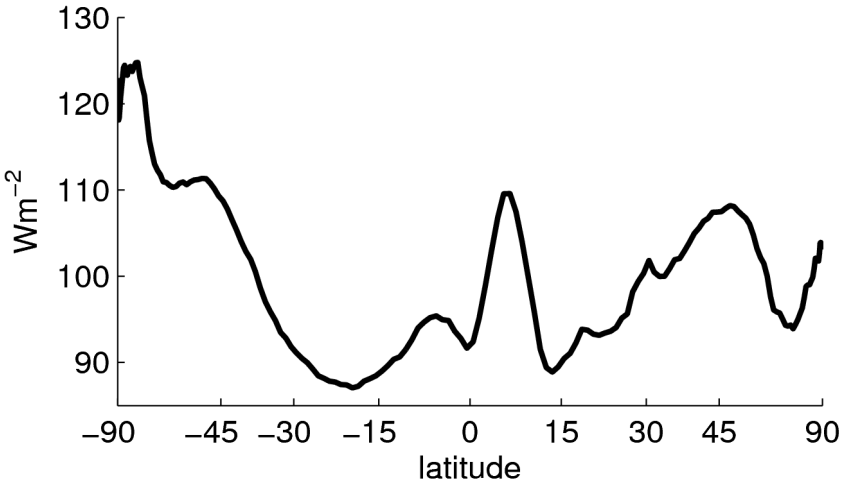
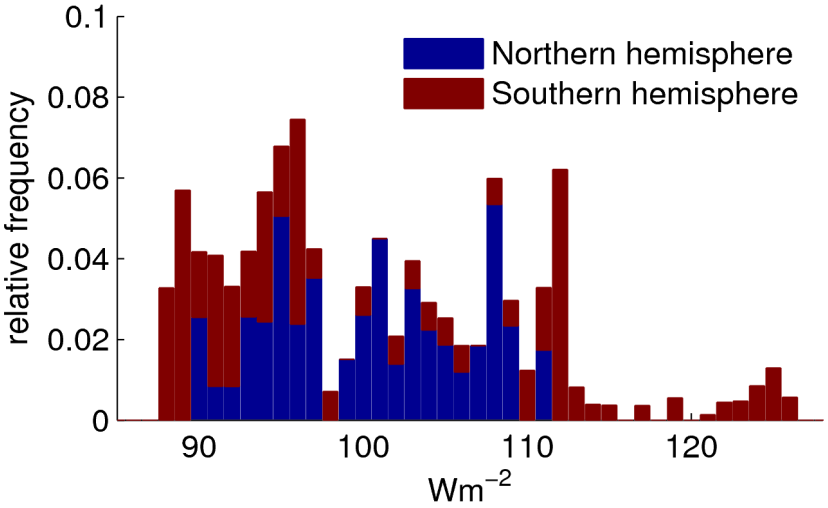
Hemispheric TOA radiation fluxes

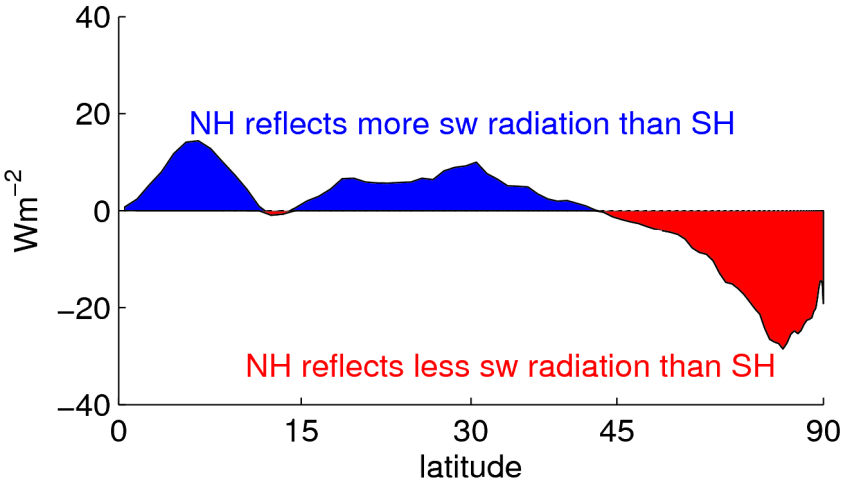
	Northern hemisphere	Southern hemisphere	difference
S	340.08	340.04	0.04
R (all)	99.42	99.56	-0.14
R (clear)	55.51	49.32	6.19
OLR (all)	240.25	238.89	1.36
OLR (clear)	267.23	264.87	3.64

Data: EBAF Ed2.5

The two hemispheres reflect the same amount of shortwave radiation



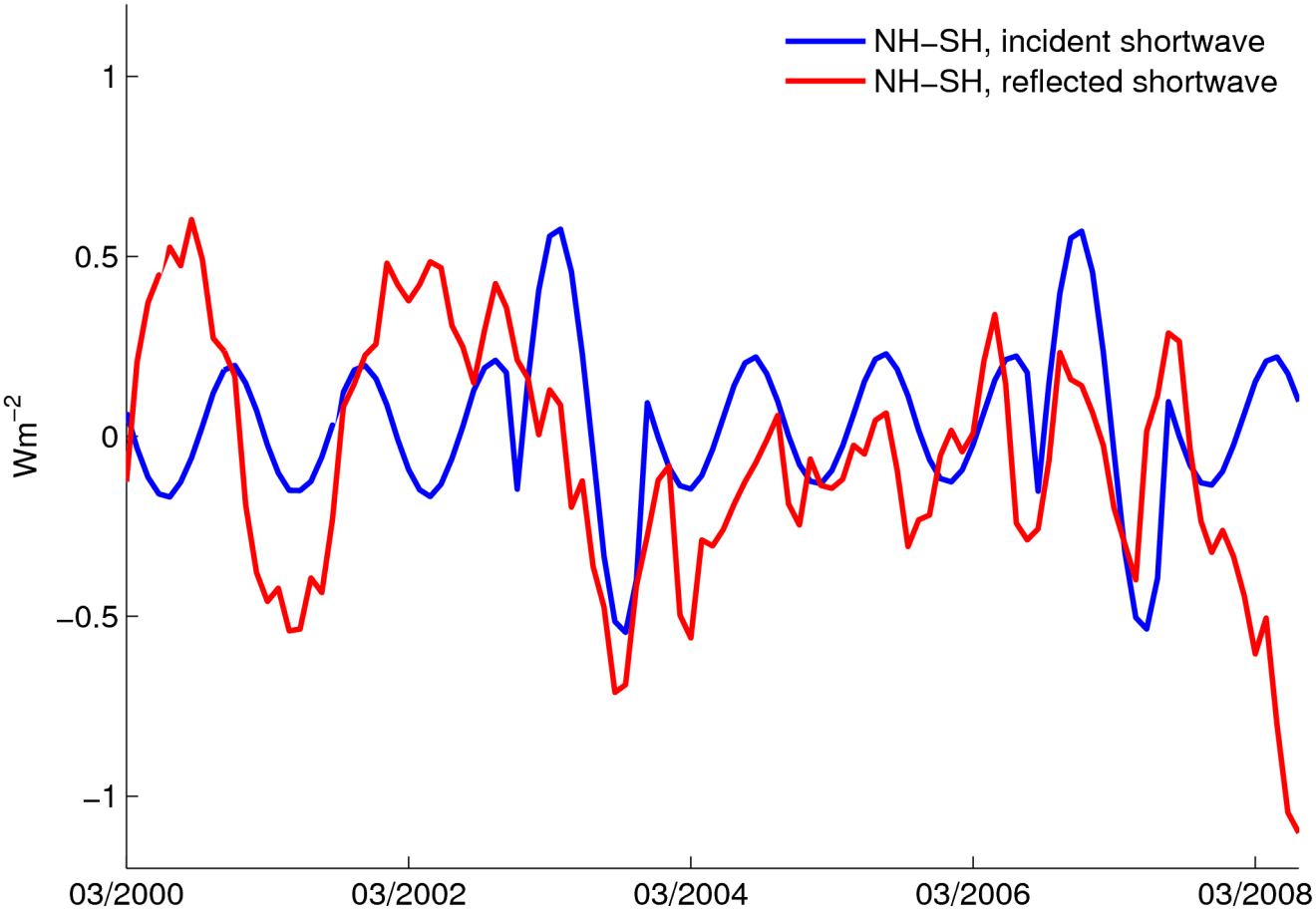




Global mean	99.5 Wm^{-2}
Northern hemisphere	99.4 Wm^{-2}
Southern hemisphere	99.6 Wm^{-2}

Data: CERES EBAF Ed2.5

Hemispheric contrast also small for individual 12-month periods



The symmetry is present in all three EBAF editions

	Northern hemisphere	Southern hemisphere	difference
CERES EBAF Ed1A (01/2001-12/2004)	99.43	99.47	-0.04
CERES EBAF Ed2.5 (03/2000-02/2010)	99.42	99.56	-0.14
CERES EBAF Ed2.6 (01/2001-12/2010)	100.03	99.84	0.19

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2. Is the hemispheric symmetry surprising?

We investigate if the symmetry is a property of any random half of Earth.

Research question

The hemispheric symmetry of reflected shortwave radiations seems a surprising property of the climate system.

However, one might suspect that the symmetry is a result of the statistic properties of the field of reflected shortwave radiation.

We test this hypothesis, and our level of surprise, by the following permutation exercise.

Testing our level of surprise

1. Consider the Northern hemisphere as a particular random half of Earth
2. Draw a different random half of Earth and calculate its amount of reflected shortwave radiation (in Wm^{-2})
3. Repeat this 10^6 times and calculate the fraction F of random halfs whose amount of reflected shortwave radiation deviates from the global mean by less than D

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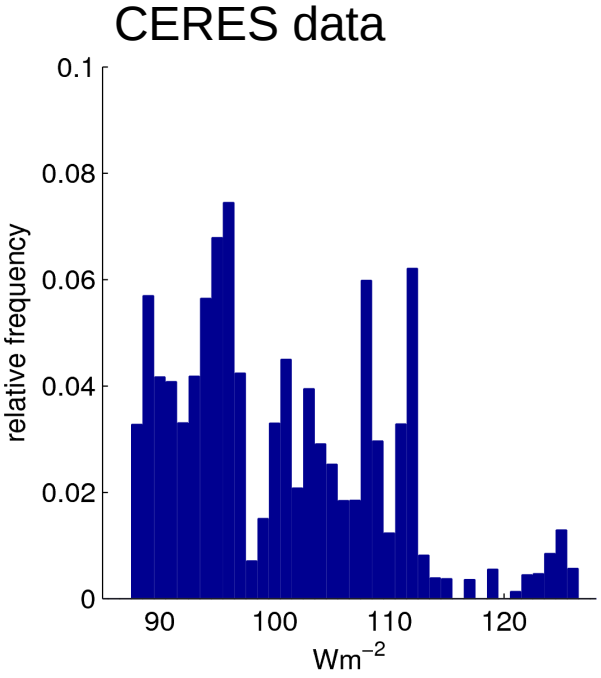
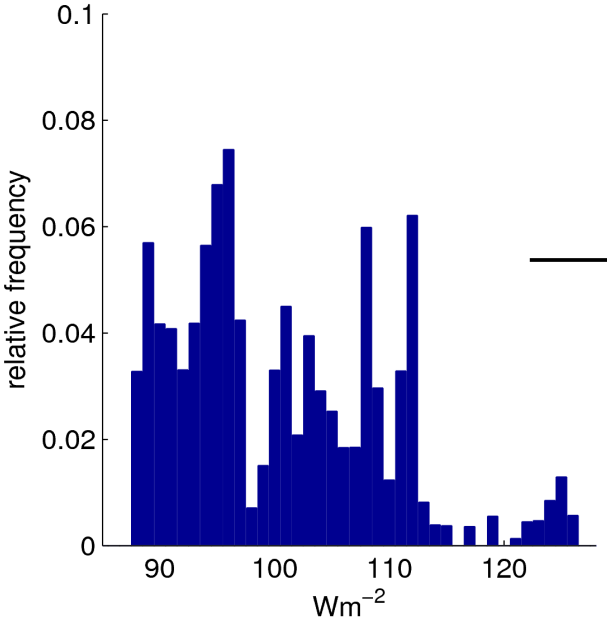
For the sake of time, we restrict ourselves to time-mean, zonal-mean data in this talk.

Testing our level of surprise (cont'd)

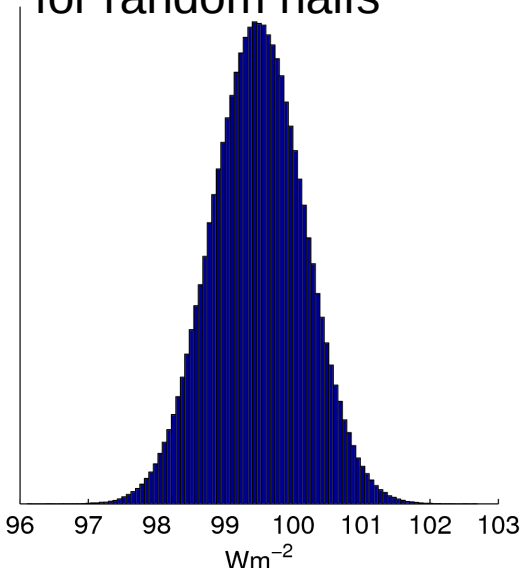


Testing our level of surprise (cont'd)

CERES data



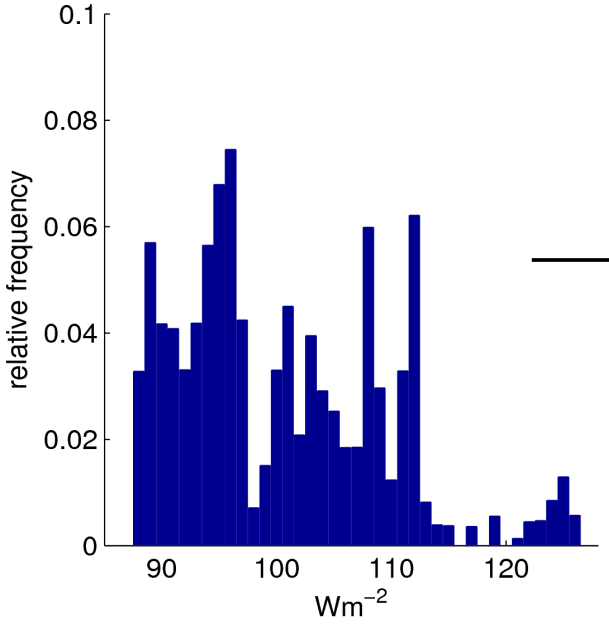
Sampling distribution
for random halfs



$$\sigma_s(1^o) = \sigma(1^o)/\sqrt{N(1^o)}$$

Testing our level of surprise (cont'd)

CERES data



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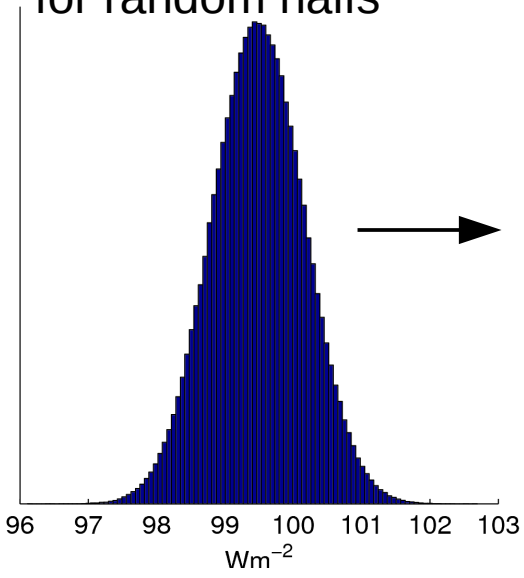

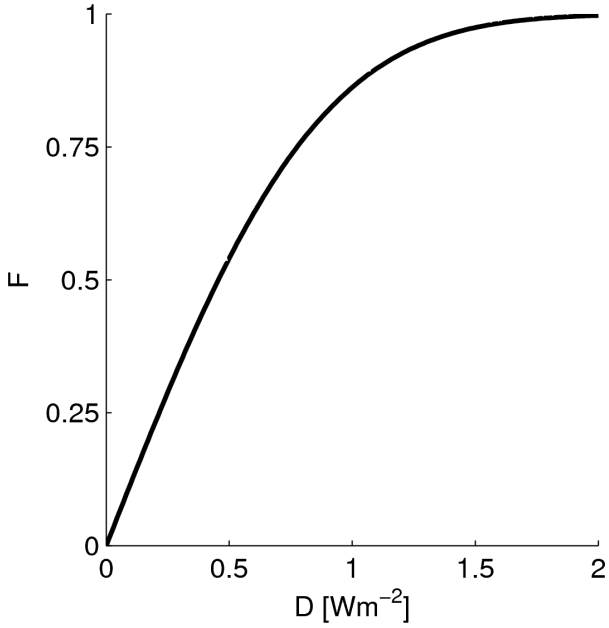

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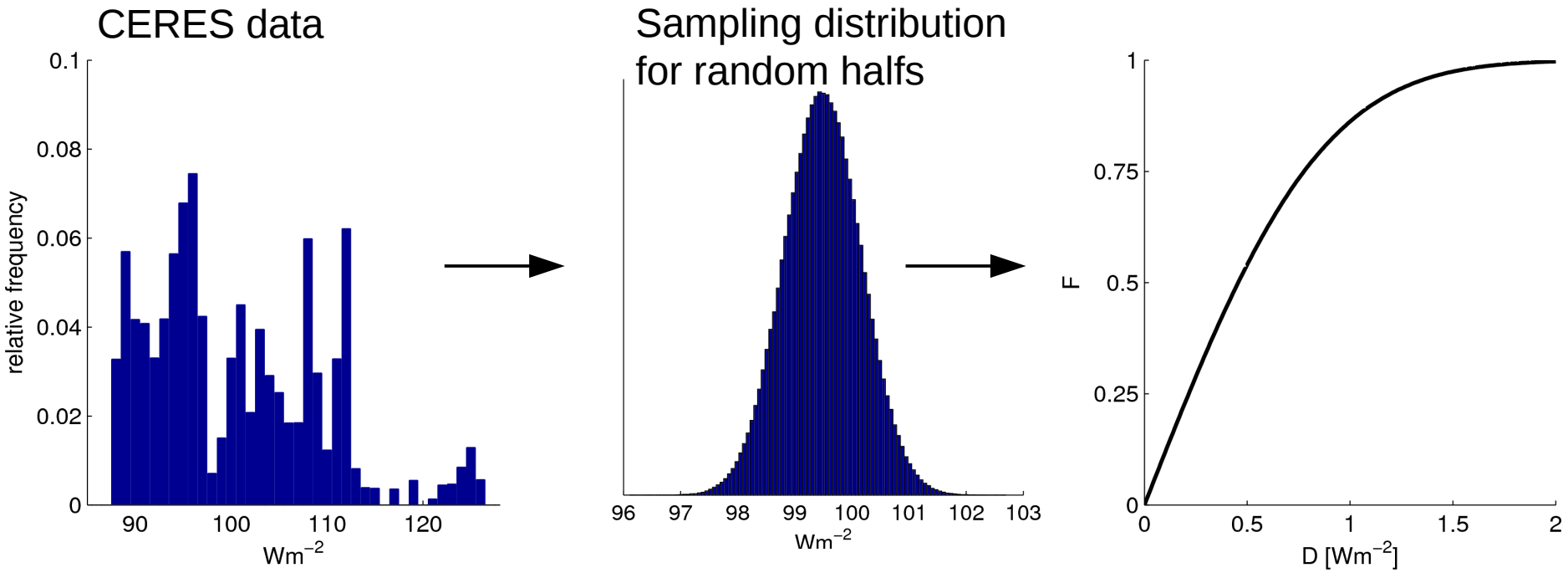

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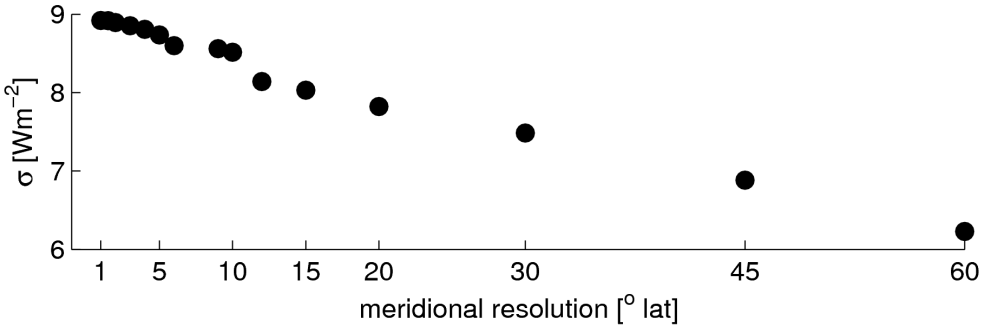
As input to our test, we need the standard deviation and the number of spatial degrees of freedom.

While the standard deviation is given, we need to estimate the number of spatial degrees of freedom.

Estimated spatial degrees of freedom

1. standard deviation on coarser grids



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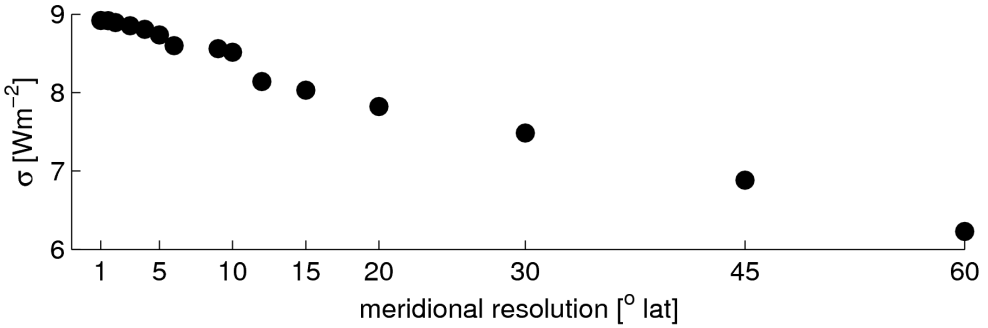
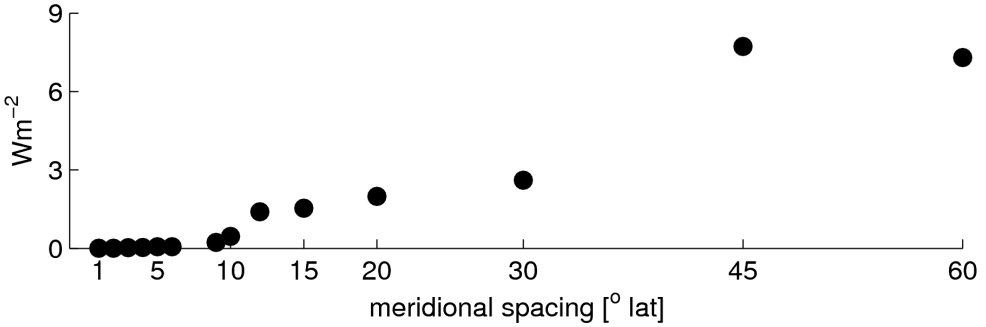


2. subsample only every n-th latitude



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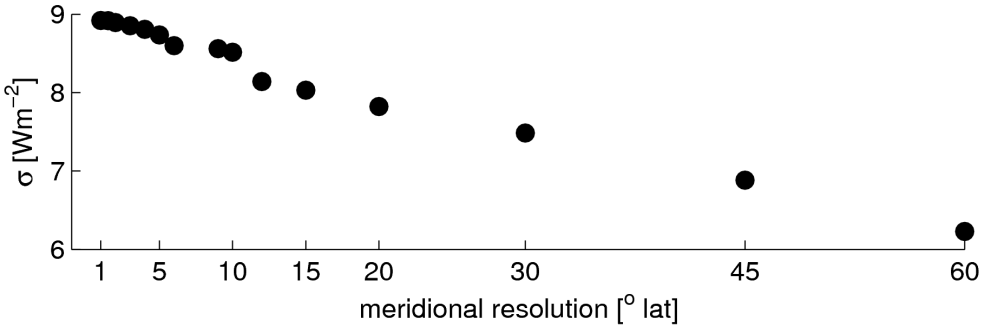

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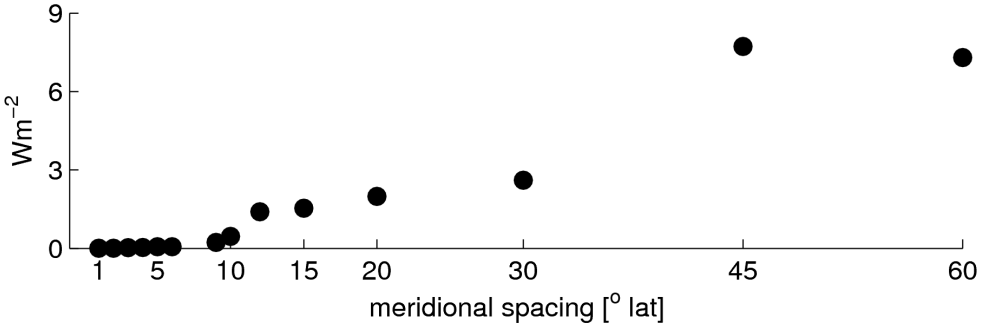
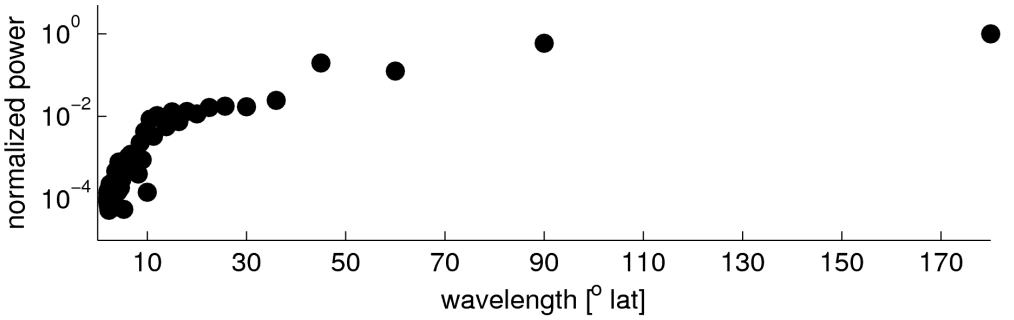


3. power spectrum in Fouriers space



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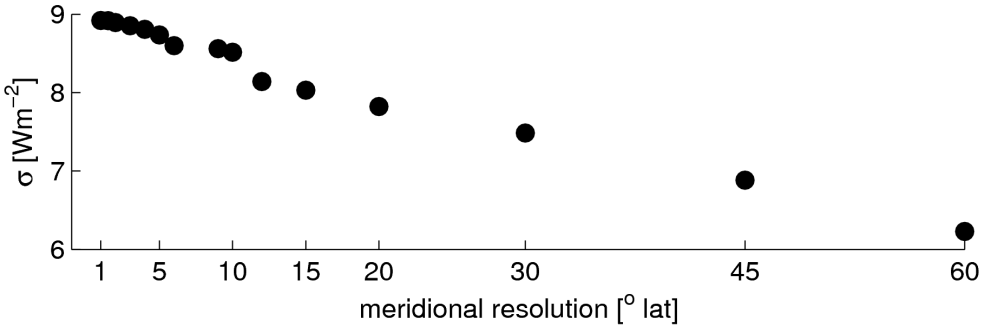

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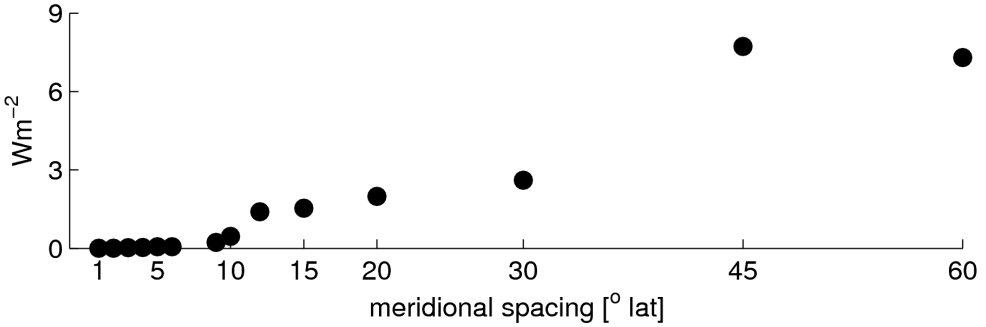

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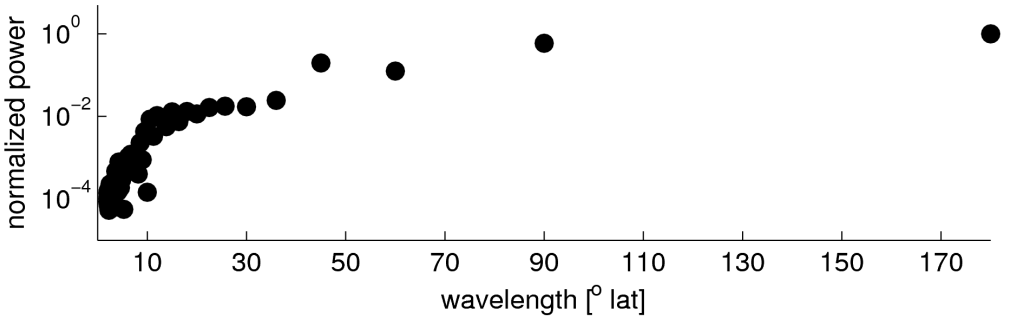
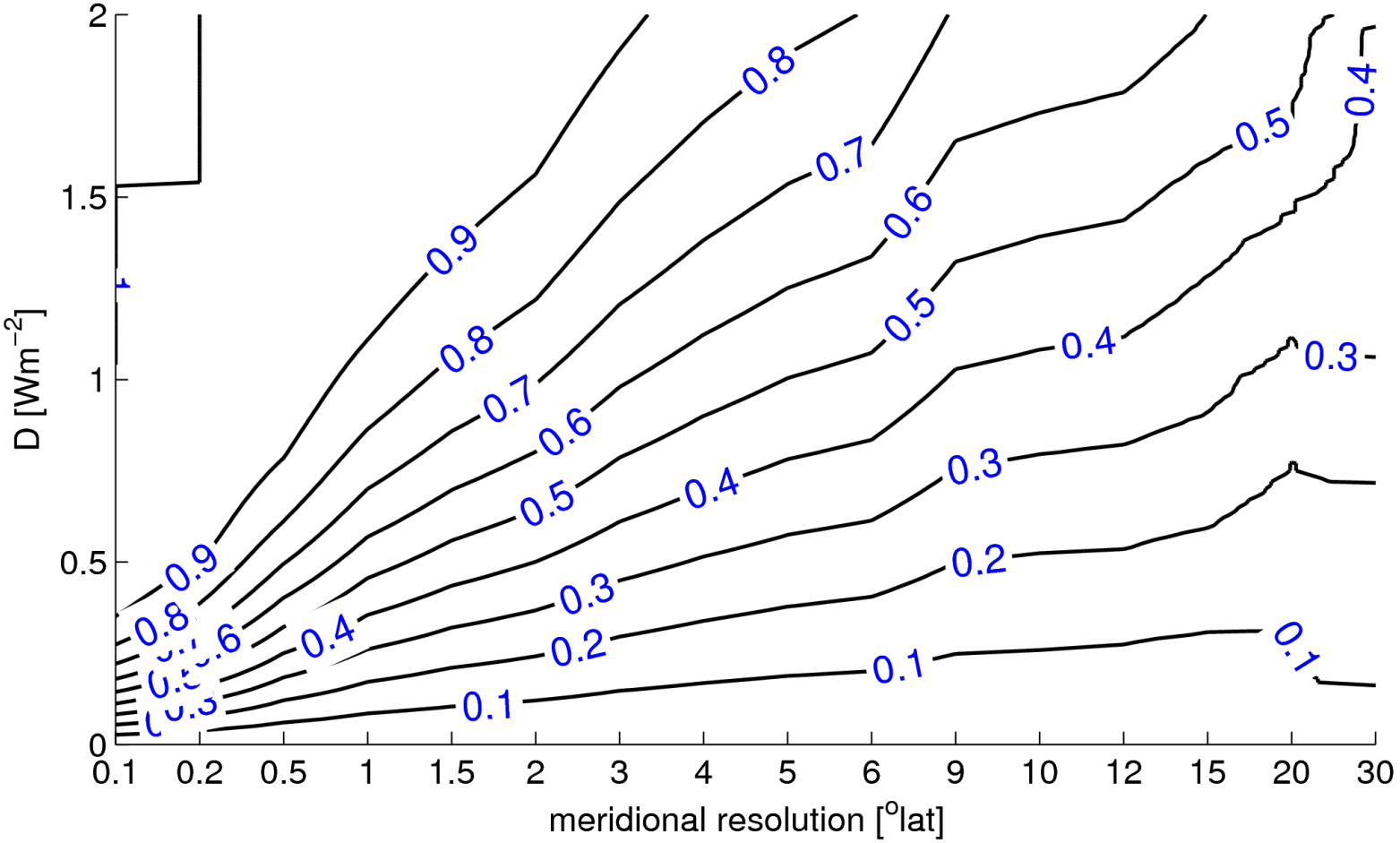


These measures indicate that every 10th latitude band is independent. This estimates N=18 spatial degrees of freedoms.

Fraction of random halfs that deviate from global-mean by less than D



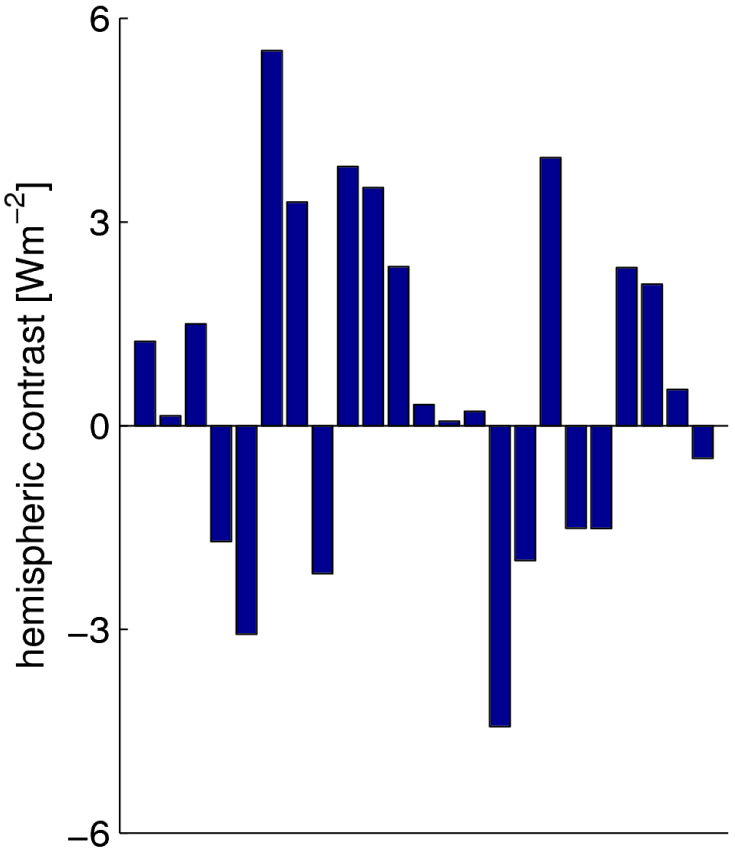
Are we fooling ourselves?

Suppose our test is biased by wishful thinking, and that indeed the hemispheric symmetry is a result of the statistical properties of the reflected shortwave radiation field.

Then, climate models should easily reproduce the symmetry.

Moreover, climate models with smaller standard deviation in reflected shortwave radiation should tend to have a smaller hemispheric difference.

CMIP3 models, pre-industrial runs



Models are asymmetric
by up to 6 Wm-2

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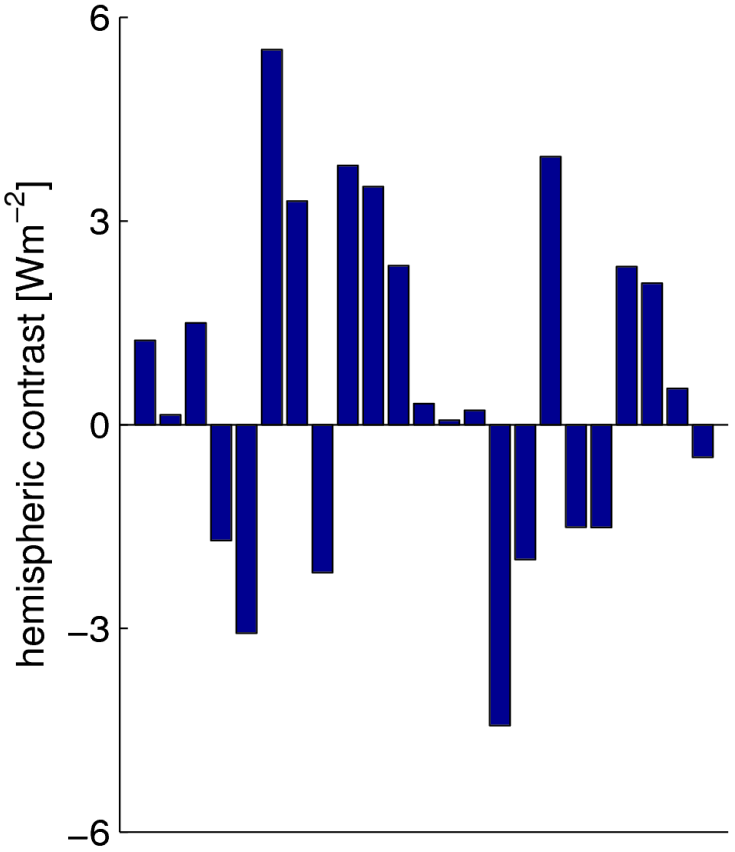

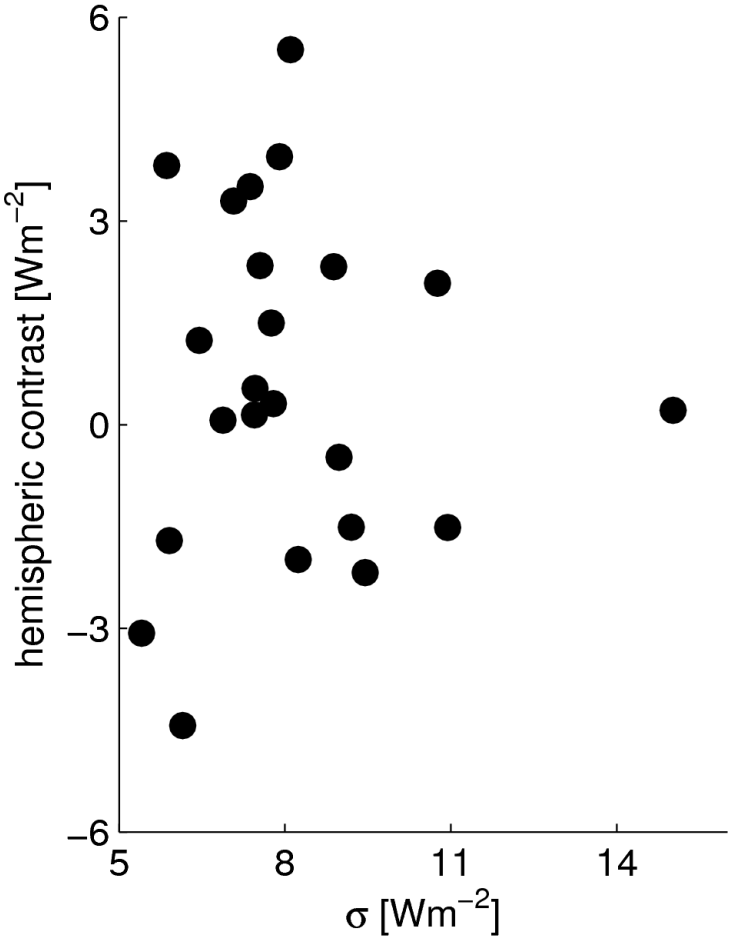

Models are asymmetric by up to 6 Wm-2

No correlation between standard deviation and hemispheric contrast

Conclusions

1. In the CERES EBAF data, the Northern and the Southern hemisphere reflect the same amount of shortwave radiation.

2. This symmetry can not be solely explained by the statistical properties of the reflected shortwave radiation field.

3. Is there a dynamical mechanism that minimizes the hemispheric contrast in reflected shortwave radiation?

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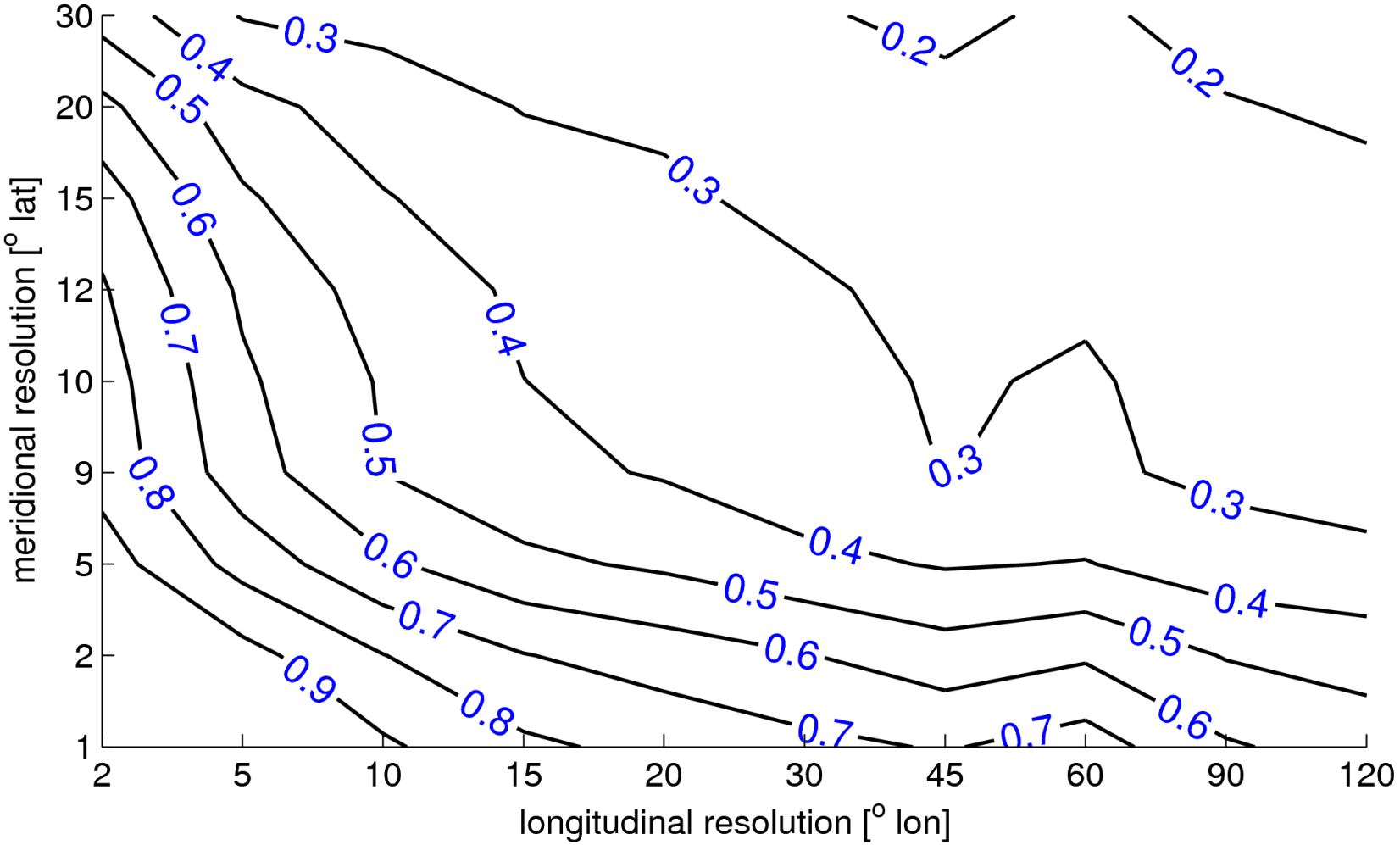
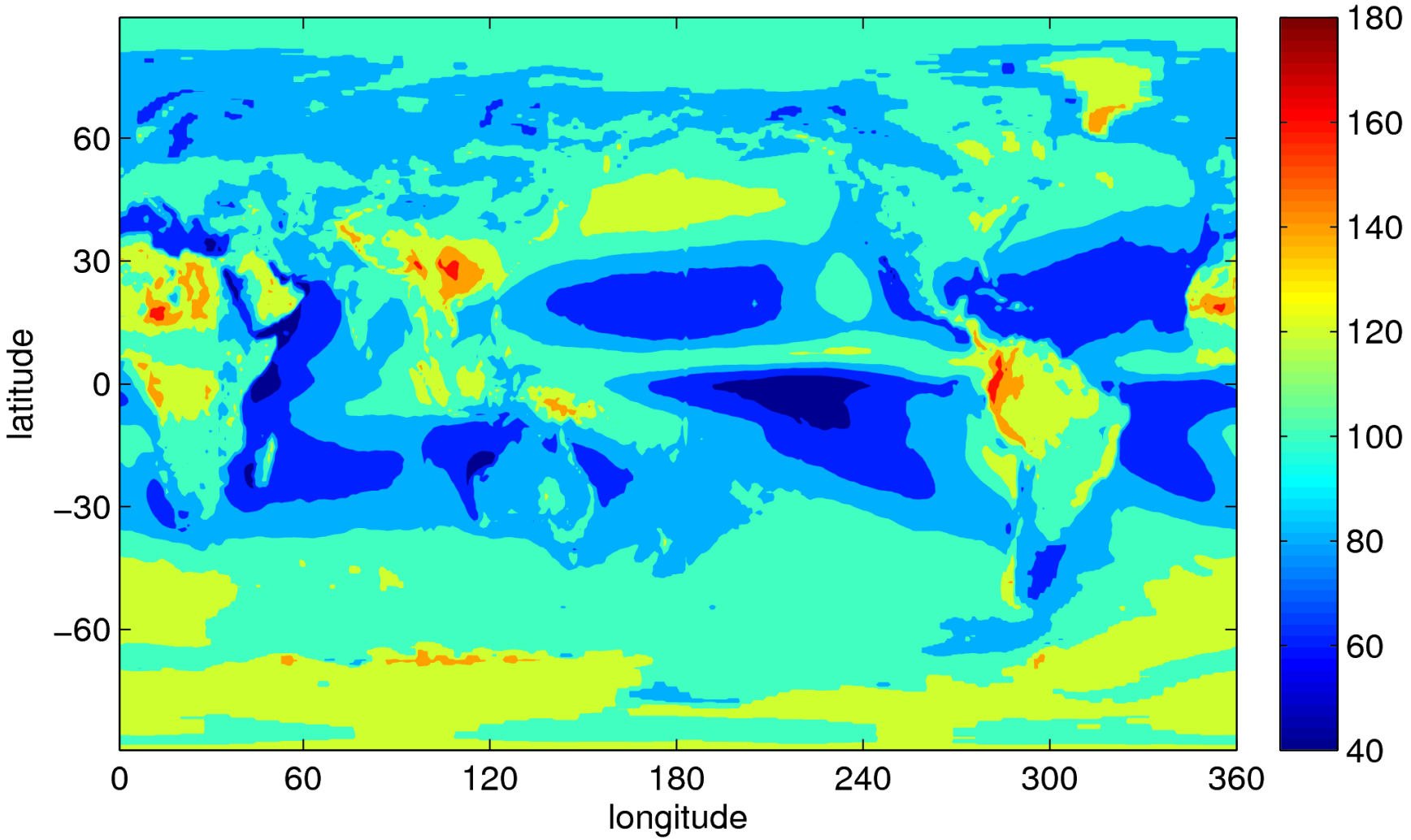
THANKS!

SPARES

Lon-lat data, D = 0.5 Wm^{-2}

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−60
0
60
120
180
240
300
360
longitude
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120
100
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60
40